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ScienceDirect
Renewable and Sustainable Energy Reviews 13 (2009) 439–449
RENEWABLE & SUSTAINABLE ENERGY REVIEWS
www.elsevier.com/locate/rser

Opportunities and challenges for renewable energy policy in China

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Received 17 August 2007; accepted 8 November 2007

Abstract

Renewable energy is the inevitable choice for sustainable economic growth, for the harmonious coexistence of human and environment as well as for the sustainable development. Government support is the key and initial power for developing renewable energy. In this article, an overall review has been conducted on renewable energy development policy (including laws and regulations, economic encouragement, technical research and development, industrialized support and government model projects, etc.) in China. On this basis, a systematic analysis has been conducted on the disadvantages of renewable energy development policy. On the point of long-term effective system for renewable energy development, a series of policy advice has been offered, such as strengthening the policy coordination, enhancing regional policy innovation, echoing with clean development mechanism, implementing process management, constructing market investment and financing system. It is expected that the above advices could be helpful to ever-improvement of renewable energy development policy.

Keywords: Renewable energy; Resources; Energy policy; China

Contents

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1364-0321/$ – see front matter
doi:10.1016/j.rser.2007.11.005

1. Introduction

Energy is a critical foundation for economic growth and social progress [1]. As economy advances and human society requires more energy, the lack of fossil energy and its pollution on the environment has given rise to the ever-serious contradiction among energy providing, environment protection and economic development. Renewable energy, with the availability of its renewability and non-pollution, will grow to be an effective and practical choice to guarantee the future development of the world [2]. As China is the largest developing country in the world, developing renewable energy is its inevitable choice for sustainable economic growth, for the harmonious coexistence of human and environment as well as for the sustainable development [3].

Renewable energy usually refers to those energies that do not pollute environment and could be recycled in nature [4]. International experts have now categorized renewable energy to be traditional and new renewable energy. The former mainly includes giant hydropower and biomass burnt directly; the latter mainly refers to small hydropower, solar energy, wind energy, biomass energy, geothermal energy and ocean energy, etc. [5]. The renewable energy mentioned in this article all refer to the latter.

2. Renewable energy resources in China

2.1. Solar energy

China is blessed with abundant solar resources. Its land surface receives an annual solar radiant energy of 1.7×10^{12} tce. More than two-third of the country receive an annual radiation of more than 5.02×10^{6} kJ/m^2 and a sunshine of more than 2000 h. Taking a look at the distribution of China's annual radiation, we find out that the areas with large amount radiation include Tibet, Qinghai, Xinjiang, southern Inner Mongolia, Shanxi, northern Shaanxi, Hebei, Shandong, Liaoning, western Jilin, middle and southwestern Yunnan, southeastern Guangdong, southeastern Fujian, eastern and western Hainan Island and southern western Taiwan, etc. Qinghai-Tibet Tableland, in particular, receives the most radiation. In most areas, except Sichuan Basin and its surrounding areas, the solar energy equals or exceeds those foreign areas on the same latitude [6].

Currently, China's solar energy is mainly intended for urban and rural domestic energy use and the power supply for remote areas. Solar water heater, passive sunshine house, solar furnace and photovoltaic cell all experience various levels of development. By the end of 2005, the installed capacity of photovoltaic power generation had reached 7×10^{4} kW; the power generation had exceeded 1×10^{5} kW, the installed area of solar water heater had exceeded 7×10^{7} m^2 [7]. According to the regulated goal, to the years of 2010 and 2020, the photovoltaic power generation could reach 3×10^{5} kW and 1.8×10^{6} kW, respectively; the solar water heater installed area could reach 1.5×10^{8} m^2 and 3×10^{8} m^2, respectively [8].

2.2. Wind energy

As estimated by *Chinese Academy of Meteorological Sciences* in the 1990s, the total wind energy reserves in China's land are 3.226×10^{9} kW, among which the developable is 2.53×10^{8} kW. They are mainly distributed in southeastern areas, Xinjiang, Gansu, northern Inner Mongolia and Northeastern China, etc.; Developable ocean wind resources are about three times that of the land, i.e. around 7.5×10^{8} kW [9].

China began to employ wind energy at an early stage. It is in 1958 that some provinces and cities began to research and manufacture 5 kW small wind energy water pumping generators. 1978 saw the introduction of 100 W and 250 W wind energy machinery to pump water and to produce power. Thanks to its simplicity in structure, this sort of equipment is applicable for pasturing area. Up to the year of 2005, a total of 61 wind power plants have been completed, with a total installed capacity of 1.266×10^{6} kW [7]. According to programs, in the years of 2010 and 2020, the wind power installed capacity of State Grid would reach 5.0×10^{6} kW and 3.0×10^{7} kW, respectively. Besides, six wind power bases would be constructed, namely, Dabancheng, Gansu Yumen, Suhu Coastal, Huiteng Xile, Hebei Zhangbei and Jilin Baicheng, etc. [8].

2.3. Biomass energy

The employable biomass energy in China mainly include crop stalks, firewood, foul wastes, domestic garbage, industrial organic waste residue and waste water, etc. It is estimated that

the total exploitable biomass energy in China is around 7×10^8 tce, among which are about 3.5×10^8 tce of crop stalks, accounting for more than 50%. Among the exploitable biomass energy resources, 40% of the crop stalks are used as feedstuff, fertilizers and industrial raw materials, and still 60%, i.e. about 2.1×10^8 tce, are used for energy; firewood are mainly used as fuel, but about 40% of the remnant forestry, i.e. about 0.3×10^8 tce, have not yet to be employed; a small proportion of the foul waste are used as fertilizer, leaving the most part, i.e. about 0.6×10^8 tce, as the principal source of pollution in rural areas; at least 80% of the industrial organic waste residue could be employed, i.e. 0.7×10^8 tce; besides, at least 0.8×10^8 tce could be generated from domestic garbage. Consequently, China's biomass energy that could be used as energy could reach at least 4.5×10^8 tce [10].

The employment of biomass energy in China includes biological chemical transition (marsh gas and fuel alcohol), the biomass gasification (power generation or thermal power co-production), biomass liquefaction (bio-diesel) and direct burning (boiler burning, dense burning and garbage burning). Up to the end of 2005, up to 1.716×10^7 marsh gas pools have been constructed throughout the country, more than 3090 large- and middle-sized marsh gas projects, with an annual production of 8.5×10^9 m^3 [11], The biomass energy power generation was 2.0×10^6 kW, the fuel alcohol 1.02×10^6 t/a and bio-diesel 5×10^4 t/a [12]. According to the goals, to the years of 2010 and 2020, the production of biological solid fuel would increase fastest, reaching 1.0×10^6 t and 5.0×10^7 t, respectively; second to that is bio-diesel, reaching 2.0×10^9 t and 2.0×10^{10} t, respectively; Fuel alcohol and biomass energy power generation would accelerate neck and neck, the former being 2.0×10^6 t and 1.0×10^7 t, respectively, and the latter being 5.5×10^6 kW and 3.0×10^7 kW, respectively; marsh gas would amount to 1.90×10^{10} m^3 and 4.0×10^{10} m^3, respectively [8].

2.4. Small hydropower

Small hydropower in China refers to the small hydropower generations with installed capacity of less than 5.0×10^3 kW (including 5.0×10^3 kW). As a counter check on the state water resources shows, the exploitable part of China's rural small hydropower resources techniques is 1.28×10^8 kW and the power generation is 4.5×10^{11} (kW h)/a. Up to 2004, the installed capacity in the exploited small hydropower plants had reached 3.45×10^7 kW, accounting for 27% of the total exploitable resources. The installed capacity of the exploited small hydropower plants accounts for 35% of the total capacity in China [13].

2.5. Geothermal energy

Geothermal energy refers to the heat contained in the rocks and geothermal fluid more than 5000 m under earth crust with the temperature above 15 °C. Located at the round-Pacific tropical zone and Himalaya–Mediterranean tropical zone, China abounds in geothermal resources. More than 3200 geothermal spots have been found, with an annual naturally relieved heat of 1.04×10^{17} kJ, i.e. 35.6×10^8 tce, among which 80% are geothermal hot land below 100 °C. This determines that China's geothermal resources are mainly directly used [10].

Currently, more than 1300 geothermal resource spots have been exploited and used, i.e. 6×10^4 tce/a. They are mainly distributed in Beijing, Tianjin, Hebei, Jiangsu, Jiangxi, Shaanxi, Guangxi, etc., employed in plantation, breeding industry, heat providing and medical service; geothermal power generations are now inadequate, which could be represented by 2.52×10^4 kW Tibet Yangbajing geothermal power plant with power generation of about 1×10^8 (kW h)/a. This accounts for 50% of the total power supply in Lhasa Grid [14].

2.6. Ocean energy

Abundant ocean energy resources are contained in China's ocean, including tidal energy, wave energy, oceanic flow energy, temperature difference energy, salt difference energy, etc. According to rough estimate, the theoretical reserve of China's tidal energy is up to 1.9×10^8 kW, the total installed capacity of developable resources is 2.16×10^7 kW and the average power generation is 6.19×10^{10} (kW h)/a, among which 90% are distributed in Zhejiang and Fujian [15]. The average theoretical reserve of wave energy resources is 1.29×10^7 kW, which are distributed in a rather uneven manner. Taiwan, with a reserve of 4.29×10^6 kW, ranks the top and takes up one-third of the total reserve. Following Taiwan are Zhejiang, Guangdong, Fujian and coastal areas in Shandong [16]. The theoretical average power in oceanic flow resources is 1.39×10^8 kW. The resources are mostly distributed in Zhejiang, which accounts for more than 50%. Following Zhejiang are coastal areas in Taiwan, Fujian, Liaoning, etc. [17]. The theoretical reserve of ocean temperature difference energy resources is around $1.19–1.33 \times 10^{19}$ kJ, the technically exploitable (heat efficiency at 7%) part is about $8.33–9.31 \times 10^{17}$ kJ; the potential installed capacity of practically employable resources is $1.32–1.48 \times 10^9$ kW, which are mainly distributed in southern Sea and the areas to the east of Taiwan; Xisha Islands, in the middle of Southern Sea, accounts for the largest proportion [18]. The reserve of salt difference energy resources is about 3.9×10^{15} kJ, with a theoretical power of 1.25×10^8 kW [19]. China's oceanic energy took its first step very late; currently, tidal energy alone has reached its maturity, leaving application of most other oceanic energy at their exploitation stage [20].

3. Current status of renewable energy development policy in China

In recently years, China has made a significant progress in the exploitation and use of renewable resources. The exploited and used renewable energy in China in 2005 reached 6.33×10^5 tce (see Table 1) [21], taking up 2.5% of the total consumed energy. Among this part, about 70% was dedicated to the domestic power use in remote and rural areas. In addition to

Table 1
Exploitation of renewable energy resources in China (2005)

Type	The exploited and used		Type	The exploited and used	
	Number	Standard coal (Mtce)		Number	Standard coal (Mtce)
Biomass energy		9.32	Solar energy		10.69
Marsh gas pool	17,160,000, production 7.06×10^9 m^3	5.55	Water heater	8.0×10^7 m^2 heat collecting area	9.60
Large-middle-scale marsh gas pool	3090, production 1.5×10^9 m^3	1.15	Photovoltaic cell	7.0×10^4 kW, 7.8×10^7 kW h	0.03
Biomass gasification	539, production 2.0×10^8 m^3	0.03	Solar furnace	686,000	0.34
Biomass power generation	2.0×10^6 kW, 4.8×10^9 kW h	1.67	Solar house	About 3.0×10^7 m^2	0.72
Biomass alcohol	1×10^6 t	0.92	Geothermal		0.65
Wind power		1.07	Direct use	6.0×10^4 tce	0.60
Small hydropower plants	3.853×10^7 kW, 1.2×10^{11} kW h	41.47	Power generation	2.8×10^4 kW, 1.4×10^7 kW h	0.05
Micro hydropower	81,000, 2.13×10^5 kW, 3.8×10^8 kW h	0.13	Total		63.33

solving the problem of rural domestic energy, China's use of renewable energy is of critical significance to the improvement of rural ecological environment, to increasing peasants' income, to the adjustment of rural industrial structure and to sustainable development, etc. However, China's renewable energy is still unable to compete with fossil energy, and its development is dependent upon the government support. Since the late 1970s, Chinese government has stipulated some principles and policies to encourage and develop renewable energy. They could be summed up as follows.

3.1. Laws, regulations and policy

In terms of laws, regulations and administrative stipulations, *Electricity Law of the PRC* has been passed in 1995, *Energy Conservation* Law of PRC in 1997 and *Air Pollution Prevention Law of PRC* in 2000, which have definitely stipulated that exploitation and use of renewable energy and new energy are encouraged [22–24]. The State Department has come up with a series of administrative regulations and systems, namely *Administration on Joint Networks Wind Power Generation*, *Further Support on the Development of Renewable Energy*, *Contents of State Encouraged Industries*, *Products and Techniques*, *1996–2010 New Energy and Renewable Energy Development Principles*, *2000–2015 New Energy and Renewable Energy Development Principles*, *Comprehensive Working Programs on Energy Saving and Emission Reduction*, etc., which have made further and detailed stipulations on the following aspects, namely, renewable energy power, renewable energy key development industry, renewable energy's development goal and renewable energy's application in energy saving and emission reduction, etc. [25–30].

On 28 February 2005, *PRC Law of Renewable Energy* was passed in the 14th session of the 10th NPC Standing Committee, bringing the exploitation and use of renewable energy to the strategic height of ''increasing energy supply, improving energy structure, guaranteeing energy safety, protecting environmental and realize the sustainable development of economy and society [31]. This marked the trend that China is to enact relevant law so as to push the development of renewable energy. Immediately after the passage of *PRC Law of Renewable Energy*, NPC and concerned sectors of State Department took quick action to stipulate relevant supporting laws and regulations, including investigations on renewable energy resources, total goal, programs on exploitation and use, industrial development content, electricity price policy, cost sharing, special capital, financial support and some other policies. Currently, a total of five sets of supporting laws have been enacted, namely, *Guidance and Content for the Development of Renewable Energy Industry*, *Temporary Method for Managing the Special Capital of Renewable Energy Development*, *Temporary Management for the Price and Cost Sharing in Renewable Energy Power Generation*, *Administrative Regulations on Renewable Energy Power Generation*, *Mid- and Long-Term Development Programming for Renewable Energy.* In *Mid- and Long-Term Development Programming for Renewable Energy*, passed by State Department on 7 June 2007, sets the general goal for the development of renewable energy: renewable energy accounts for up to 10% of the total energy structure in 2010 and 16% in 2020 [32]. *Agricultural Biological Mass Energy Industrial Development Program (2007–2015)*, conferred by Department of Agriculture on 3 July 2007, has pointed out the detailed goal for the development of rural biomass energy: up to 2015, the total rural user of marsh gas should reach 6.0×10^7, the annual marsh gas production reach 2.33×10^{10} m^3; 8000 large- and middle-sized marsh projects should be constructed with an annual marsh gas production of 6.7×10^8 m^3; at the mean time, a batch of crop stalk solidification fuel application model spots and crop stalk gasification central gas providing stations should be constructed, so as to take advantage of the marginal land to properly develop energy crops and to meet China's need for raw materials of fluid fuel [33].

3.2. Economic encouragement policy

(1) Financial subsidy

Financial subsidy is the most conventional economic encouragement practice. Varying in forms, the subsidy could be categorized to be investment subsidy, product subsidy and user subsidy. Investment subsidy, as its name indicates, refers to the direct subsidy to the renewable energy programs' developers and investors. Chinese government has set up a rural energy special cashing interest loan since 1987, RMB 1.2×10^8 yuan each year, with the cashing interest rate at 50%. This amount is mainly used for wind power generation, solar energy heater techniques, the technical research and development, reconstruction, promotion and application of large- and middle-sized marsh gas pools [34]; product subsidy are rarely seen in China. *Temporary Management for the Price and Cost Sharing in Renewable Energy Power Generation* is the only regulation that contains product subsidy, stipulating that the subsidized electricity price for biomass power generation is RMB 0.25 yuan/(kW h). Since the beginning of the power generation program, it will enjoy the subsidized electricity price for 15 years [35]. User subsidy is the most conventional subsidy in China. As *Rural Marsh Gas Construction State Debt Program Management Method* stipulates, central finance subsidizes the ''one pool and three reforms'' in accordance with the following standards: RMB 1200 yuan/household in northwestern and northeastern areas, RMB 1000 yuan/household in southwestern area and RMB 800 yuan/household in other areas [36]; some local government has provided some subsidies for the development and exploitation of renewable energy, for instance, local government of Tibet, Qinghai, Inner Mongolia provide a subsidy of RMB 100–300 yuan/set to the peasants and cowpunchers in remote areas who purchase solar photovoltaic power generation system and small wind power generation system [34].

(2) Favorable taxation policy

Favorable taxation policy is a most universal encouragement policy in the world currently, but it is narrowly applied in China's renewable energy development. Only some areas could find its presentation, mainly including: the value added tax for small hydropower is reduced from 6% to 3% [37]; value added tax for wind energy power generation is reduced by 50%; the importation of some renewable energy power generation equipment and their parts that China is unable to produce (including key parts of photovoltaic cell and large wind energy power generation equipment) now shall be exempted form taxation; or in some cases, the tax is reduced [38]. The income tax of renewable energy production enterprises have been exempted by some local government, for instance, Xinjiang, Inner Mongolia, etc. These enterprises enjoy the same favorable conditions as the high and new technology industrial enterprises. Like the projects within Great Western Development, the renewable energy power generation projects constructed in western area could enjoy the tax exemption policy.

(3) Favorable price policy

Favorable price policy is mainly intended for network power produced with renewable energy, represented by guaranteeing the network access and favorable electricity price. In 1994, the previous State Power Department issued *Management on Joint Operation of Wind Energy Power Plant*, requiring Grid management sectors to allow wind power plant to access the networks at the nearest access point, and to purchase all the power that has accessed the networks; the network electricity price should be fixed in conformance to the principle of paying back the loan and interest and making reasonable profit; the part above the networks shall adopt average electricity price, and the price difference shall be shared equally by the entire grid [25]. In 1999, the previous State Planning Committee and Science and Technology Department issued ''Notice on Further Supporting Renewable Energy'', confirming the above-mentioned policy [26]. On 28 March 2005, *Temporary Method for Managing Grid Electricity Price* was issued by State Commission of Development and Reform, stipulating that new energy and renewable energy enterprises such as wind energy power and geothermal energy did not participate in the competition for the time being; Grid enterprises should enjoy the priority in purchasing power at government-set price or bidding price. At proper time, government should stipulate the proportion that new energy and renewable energy take in the power provided by power supplying enterprises, and establish special competitive new energy and renewable energy markets [39]. In terms of hydropower generation, Chinese government should implement the new electricity price and the loan plus interest electricity price. Besides, the government should give special treatment to small hydropower plants; the ''power plants cultivated by power plants'' policy should be implemented to protect the development of small hydropower plants.

In terms of non-electricity use of renewable energy, measures have been taken in some areas to adopt a protective price. For instance, Shanghai has the policy of selling marsh gas at a high price, fixing its price at RMB 1.20 yuan/m^3.

In accordance with the requirement to implement the *PRC Law of Renewable Energy*, State Commission of Development and Reform is now on its way to stipulate some policies on renewable energy power generation, which are expected to be issued soon.

3.3. Industrialized support policy

In recent years, Chinese government has implemented State Technical Problem Tackling Plan, high technology research plan, industrialized development special item and key equipment special item, etc. Through these doing, the government is to support the use of solar energy, photovoltaic power generation, wind energy power generation equipment and their parts. Besides, the government has accelerated the localization and state manufacturing process of renewable

energy equipment, constructing the largest water heater industry around the world; in terms of photovoltaic power generation products, some enormous enterprises have come into existence, such as Wuxi Shangde, Tianweiyingli, Xinjiang New Energy, etc. In terms of wind energy power generation equipment manufacturing, the entire equipment manufacturing enterprises made their appearance, including Xinjiang Jinfeng, Zhejiang Yuanda, etc. Besides, a series of parts manufacturing enterprises have shown up too, such as Chongqing Gear, Huiteng Vane, Yongji Machinery, etc. These enterprises have laid a solid foundation for the long-term development of China's renewable energy equipment manufacturing industry. Since 2002, State Commission of Development and Reform has initiated Wind Power Concession Bidding Project and developed several 1.0×10^5 kW wind energy power generation concession projects. This has reduced the cost of wind energy power generation and gradually increase the proportion of China-made wind energy equipment. A batch of giant equipment manufacturing enterprises from both home and abroad have been attracted to enter the field of wind energy power generation, such as Shanghai Electronics, Harbin Electronics, Dalian Heavy Industry, Aviation Corporation, Xinjiang Tebian Electronics, etc.; besides, some world renowned enterprises such as GE, Vistas, Simens, Gemisa-Kelaosai is have already or are about to enter China's wind energy power generation manufacturing industry. It's expected that China is to grow up to be a giant country of wind machinery manufacture around the world in the coming 3–5 years [31].

3.4. Technical research and development policy

As a newly risen industry, renewable energy abounds in technical bottlenecks. Chinese government has long been attaching importance to the technical research and development on renewable energy. Since the sixth Five Year Plan, Chinese government has implemented State Technical Problem Tackling Plan (since 1982), 863 Plan (since 1986), 973 Plan (since 1997), arranging capital to support the research on the development and techniques of renewable energy, such as wind energy, solar energy, biomass energy, geothermal energy and ocean energy, etc. The research and development of renewable energy are included in many projects, namely, all the Five Year Plans, the Bright Project and Fair Wind Project by the previous State Planning Commission, the Dual Pluses Project and Rural Household Marsh Gas State Debt Project by previous State Commission of Economy and Trade. In *Mid- and Long-Term Development programming for Renewable Energy* which was passed on 7 June 2007, the goal was set that central finance will set up special fund for developing renewable energy in support of the technical research and industrial construction of renewable energy.

3.5. Government renewable resources model projects

The development of China's renewable energy, especially the large projects, is closely related to the promotion of government model projects. The Table 2 is the list of principal government model projects since the 1990s.

4. Disadvantages of renewable energy development policy in China

Thanks to the over three decades of development, China's renewable energy policy has now grown up and played an important guiding and pushing role for the development of renewable energy. With the continuous change in environment, however, China's renewable energy development policy begins to show certain disadvantages, which could be best presented by the following.

4.1. Lack of coordination and consistence in policy

Since long ago, the responsibility for China's renewable energy business goes to many sectors; for instance, State Commission of Economy and Trade, Department of Agriculture, Department of Water Conservation, previous Department of Power, previous Department of Forestry all have special sectors in charge of renewable energy. This issue has been governed by many sectors at the same time, which substantially undermines the state macro-control. A great number of policies and model projects come from various sectors. Due to the difference in goals, it's rather difficult to get consistence in the energy policy in the same field. Besides, energy policies in different fields lack coordination, making it difficult to form a long-term and effective system to support renewable energy's sustainable development. For instance, in order to reduce the investment cost in wind energy power plants, China canceled the tariff for importing wind energy power generators; while on the other side, the concerned sectors had been making active efforts to support the China-manufacturing process of wind energy power generation equipment, and implementing some model projects for the China-manufacturing process. The different goals in the two policies plays positive and negative roles respectively for the development of domestic wind energy power generation equipment manufacturing, thus undermine the effectiveness of policy.

4.2. Weakness and incompleteness in encouragement system

Let us take financial subsidy as an example. When it comes to China's subsidy to renewable energy investment projects, small scope and little amount is the very foremost problem. Except the project of ''Delivering Power to Village'', most subsidies are symbolic, and is less than 10% of the total investment; besides, these subsidies tend to be jammed in their transmission to the lower level of units, making it difficult to reach the lower level of units smoothly. China's force in supporting renewable energy through taxation methods is fairly weak; the actual taxation of most renewable energy projects is quite close to that of conventional energy, and some even higher than that of conventional energy. This

Table 2
Government renewable energy model projects in China

Time	Project	Initiating institution	Brief introduction
1996	Bright Project	State Commission of Development and Reform	Provide renewable power to 2×10^7 Chinese citizens
1996	Fair Wind Project	State Commission of Development and Reform	During the 10th Five Year Plan, 60–80% or more wind machinery produced by China
1997	Dual Pluses Project	State Commission of Economy and Trade	Invest RMB 9×10^8 yuan to accelerate wind energy power generation and the wind energy machinery state-manufacturing process
1998	Crop Stalk Gasification Project	State Planning Commission	Support the general rural area to promote and extend the crop stalk gasification techniques
2000	State Debt Wind Energy Power Generation	State Commission of Economy and Trade	Construct 8×10^4 kW China-made wind energy power generation group model wind power field
2000	Tenth Five Year Plan	State Commission of Development and Reform	Up to 2005, the installed capacity for wind power generation reached 1500 kW
2000	Renewable Energy Industrial Development Plan	State Commission of Economy and Trade	Up to 2015, the installed capacity for wind power generation reaches 7000 MW
2002	Acceleration Plan for Bright Project	State Commission of Development and Reform	Provide a capital of RMB 1.8×10^9 yuan for solar energy and wind energy projects
2002	Electricity Delivered to Village Project	State Commission of Development and Reform	Solve the domestic power problem for 4.0×10^5 citizens
2003	Six Smalls Project	State Commission of Development and Reform	Water conservation and irrigation, human and animal drinking, rural road, rural water and electricity, pasture barrier and some other projects
2003	Rural Household Marsh Gas State Debt Project	Department of Agriculture, State Commission of Development and Reform	Construct the marsh gas construction with state debt capital
2006	Scaled Development Project on Renewable Energy	Chinese Government, World Bank, World Environment Fund	Study and formulate the policy for the development of renewable energy; support the technical advances in renewable energy; construct an industrial system for renewable energy; to realize the scaled development of renewable energy
2007	Rural Marsh Gas Projects	Department of Agriculture	In 2010, the total marsh gas users reach 40 million; the large- and middle-sized marsh gas projects reach 4700
2007	Supporting Projects for Biological Mass Energy Science and Technology	Department of Agriculture	Establish technical innovation centers in biological energy regions
2007	Use of Crop Stalk as Energy Source	Department of Agriculture	Construct 400 village-/town-level crop stalk solidification fuel model spots and 1000 crop stalk central gas providing stations
2007	Selection and Cultivation Model Base Construction Projects on Energy Crops	Department of Agriculture	Construct energy crops quality seeds selection and cultivation base; construct bases for raw materials for fluid fuel

could not present the favorable conditions and policy for renewable energy. For instance, in according to the concerned favorable policies, RMB 0.25 yuan/(kW h) should be given to biomass energy power generation [39], so that the power price could lowered to a little bit more than RMB 0.6 yuan/(kW h), but this price is still about RMB 0.2 yuan/(kW h) higher than that of conventional power, plunging the biomass energy power generation into the bad at the very beginning. This has not conformed to article 19 of *PRC Law of Renewable Energy*, regulating that ‘‘the networks power price for renewable energy should be fixed on the principle of pushing the development of renewable energy and the principle of being economical and reasonable’’.

4.3. Lack of innovation in regional policy

China is blessed with enormous territory, which gives rise to a giant difference between the east and the west, including difference in renewable energy resources reserve, difference in population size and marketization brought about by economic and social development, and difference in idea and systems caused by history and tradition. Measures have yet to be adjusted to local conditions in terms of existing regional renewable energy policies; the state macroinstruction policy is still working across the country. The regional renewable energy’s comparative advantage and industrialized competitive advantages have not been defined in accordance with the actual

local conditions, which enormously hinders the development of renewable energy industry. How could we objectively judge the development features and development stage in object region? How could we innovate regional policy in accordance wit various regional characteristics? This has now become a noteworthy question for all local government in formulating regional renewable energy policy.

4.4. Incomplete financing system for renewable energy projects

Since long ago, the investment of China's renewable energy projects, especially the giant model projects, have mainly depended upon three sources: government funding and loan, donation and loan from foreign government and international institutions and foreign merchants' direct investment. Main body of the investment is more than single; domestic enterprises have not yet to invest enough; as the real investment man body of industrialized development, enterprises have not been blended into the development chains in a real sense, making it rather difficult to form a sustainable power system for industrial development; in addition, foreign merchants' direct investment might lead to the phenomenon that the foreign competitors might monopoly the renewable energy product market in China, especially the high-end technical market. In this situation, the industrial security and energy security shall be endangered, limiting the sustainable development of renewable energy.

4.5. Inadequate investment in the technical research and development for renewable energy

Renewable energy is a technique-intensive and fund-intensive industry. Its the requirement of the stable and rapid development that we break through the technical problems first. Currently, China has ranked top in terms of investment on renewable energy; the investment reached 6.0×10^9 USD in 2005, but very small proportion are applied in technical research and development. As statistics shows, China's investment on the research and development of renewable energy took up only 0.045% of the total GDP, while EU member countries' investment accounted for 2% of the GDP [40], which is about 44 times higher than that of China. China's technical research and development in renewable energy lack adequate investment, leading to the fact the some advanced techniques and equipment depend much upon importation. For instance, 70% of the wind energy power generation machinery group came from importation in 2005, which is the most important reason why the cost remained high; spathic-silicon materials, raw materials for photovoltaic cell, must depend upon importation, leaving the industrial development at a rather passive situation and its future not so promising.

5. Policy advice on renewable energy development in China

With regard to the abovementioned problems in China's renewable energy development policy, standing on the point of long and effective system in renewable energy development, we have carried out systematic and insightful thought upon the policy optimization and innovation. It is hereby advised that importance should be attached to the following aspects in China's renewable energy development policy.

5.1. Improving the effectiveness of policy completeness and policy grouping

Government support is the key and initial power for the development of renewable energy. China's renewable energy is usually promoted and pushed in some remote and poverty-stricken areas, where social efficiency is remarkable while economic efficiency rather low. Thus renewable energy needs more encouragement and support from the nation and all levels of government. *PRC Law of Renewable Energy*, issued on 28 February 2005, fixed the legal position of renewable energy and defined the development direction of renewable energy. Its effective implementation depended much upon some supporting administrative laws, regulations, technical regulations and relevant programs and plans issued by State Department and some concerned sectors. The already issued supporting regulations include five sets of supporting laws, namely, *Instructions on Renewable Energy Industry Development, Management Regulations on Renewable Energy Power Generation*, *Temporary Management for the Price and Cost Sharing in Renewable Energy Power Generation*, *Administrative Regulations on Renewable Energy Power Generation* and *Mid- and Long-Term Development Programming for Renewable Energy.* State Commission of Development and Reform is now on its way to stipulate some policies on renewable energy power generation, which is expected to be issued soon. To ensure the successful implementation of these laws and regulations, we should construct an effective system, with PRC Law of Renewable Energy as its dragon head and closely surrounded by supporting laws and regulations.

Since 1979, Chinese government has issued quite some laws, regulations and policies in terms of renewable energy; however, China's renewable energy is charged by more than one sector. This results in the lack of consistence between policies, hindering the development of renewable energy industry. The state should set up a special governing sector for renewable energy, responsible for the unified formulation, programming and management of policies, for coordinating various policies. In this way, we could better exert the role of combined policies, and formulate a long-lasting and effective mechanism to support the sustainable development of renewable energy.

5.2. Enhance the policy innovation in policy regions

Development of renewable energy must be based upon the regional situation; and the issues should be studied in accordance with the local conditions. The formulation of regional energy development policy should consult the state mid- and long-term programming on renewable energy; besides, in the programming, we should strengthen our

investigation on the regional energy distribution so as to form a reasonable regional layout for industrial development; in addition, we should play an active role in encouraging regional-industry-related policies to make innovations, and ultimately reaching a benign circle of "regional policy extension"—"regional policy innovation"—"regional policy further extension". In this way, the blood making mechanism could be formulated by and large, constituting the sustainable guided transition for energy use.

5.3. Construct the regional echoing mechanism for clean development mechanism

In order to tackle the problem of world-wide warming up, Clean Development Mechanism (CDM) was put forward in Tokyo Protocol, allowing developed countries to provide additional capital and techniques to reduce the greenhouse gas emission in developing countries. Besides, the reduced emission should be regarded as emission reducing obligations for developed countries; while on the other side, the additional capital and techniques acquired by developing countries are helpful to their own sustainable development. Tokyo Protocol has now entered the phase of implementation; Chinese government adopts an active attitude toward the development of CDM. Up to 26 March 2007, China has developed 279 CDM projects in all; when all the projects are working, their emission reduction accounts for 50% of the total CDM emission reduction in the world [41]. Currently, China has just made its first step in CDM emission reduction market, leaving us an enormous potential.

Most of China's CDM projects lie in renewable energy field, including wind energy power generation, small hydropower plants, photovoltaic cell, solar energy water heater, biomass power generation, rural marsh gas and garbage burying gas, etc. As is estimated, the carbon emission potential in this field would reach 6.28×10^7 t in 2010 and 1.98×10^8 t in 2020 [42]. With substantial investment and high cost, China's renewable energy is quite appropriate to serve as CDM project. Consequently, Chinese government should actively echo with CDM, take advantage of CDM, construct the regional echoing mechanism for CDM, striving for more capital and techniques for renewable energy development. In this way, we could accelerate our step in enlarging the development of renewable energy.

5.4. Enlarge investment on research and development

As renewable energy development in developed countries shows, renewable energy, as a newly risen industry, though has a rather promising future, is in great need of government fund support in the beginning. Currently, China's investment in technical research and development of renewable energy is inadequate, leading some advanced techniques and equipment to severe dependence on importation. This has plunged the industrial development into a fairly passive situation.

It's been advised that the state arrange a certain part of special capital for renewable energy so as to strengthen the technical research and development of renewable energy, to enhance our own innovative capability; in accordance with the maturity of renewable energy techniques, the government should provide sustainable fund subsidy to technical research and development projects stage by stage, so as to reduce investment risk of individual enterprises, to enhance their activity in participating the technical research and development; at the mean time, state-made wind energy power generators manufacturers and state-made photovoltaic cell manufactures should be subsidized. Through this doing, we are aimed at accelerating the localization and state-made process of renewable energy equipment manufacture and at promoting the sustainable and healthy development of China's renewable energy industry.

5.5. Develop process management, ensure the effective function of policy

Some policies related to China's renewable energy tend to get unsmooth in their transmission to lower level of units, leading to the trouble that the function of policies are sometimes undermined. As for this phenomenon, renewable energy development offices should be set up by the state at various levels of government, which would be in charge of policy implementation and industrial dynamic management; at the mean time, monitoring teams should be set up under these sectors specially to monitor policy conveying and implementation. Besides, these teams should report and feedback their information to their supervisors from lower levels of units. Upper levels and lower levels complementing each other thus form a complete and powerful policy system. In addition, in the formulation and management of industrial development policies, renewable energy development offices should keep consistence in policy implementation as well as considering the risk and predicament that the changing environment brings to policy implementation. In this way, the offices are able to actively push the organic regulation, control and the reasonable optimization of industrial policies.

5.6. Construct a market investment and financing system

Establishing the relevant investment and financing mechanism is a key condition for renewable energy technical industrialization. Currently, the main body of China's renewable energy is over single; the investment and financing channels are not expedite; and domestic enterprises have not invested enough in this field. In order to formulate a long-term and effective development mechanism for renewable energy, we should made enormous efforts on exploring renewable energy's capital market, including enlarging the government support, strengthening the back support and bring into full play the Build–Operate–Transfer energy fund, stocks and public fund, and some other market financing methods. In this way, we could build up a market investment and financing system. In this system, the state offer guidance with limited amount of capital while bank loan and self-raised capital shall play a more important role in enterprises.

6. Conclusions

Renewable energy is the inevitable choice for sustainable economic growth, for the harmonious coexistence of human and environment as well as for the sustainable development. In order to promote and ensure the rapid, effective and sustainable development of renewable energy, Chinese government has formulated a series of policies on renewable energy development, including laws, regulations, economic encouragement, technical research and development, industrialized support and government renewable energy model projects, etc. These policies play a significant pushing and guiding role in the development and use of renewable energy; With the continuous change in environment, however, China's renewable energy development policy begins to show certain disadvantages, which could be best represented by the following: (1) polices lack coordination and consistence; the coordinative function has not been brought to play; (2) the encouragement policy is inadequate and the system is not complete; government subsidies do not cover enough areas; the subsidies are small and not smooth in their transmission to lower levels; (3) lack of regional policies innovation; comparative advantages and industrialized competitive advantages have yet to be formulated in regional renewable energy; (4) investment and financing system is not healthy and complete; main body of the investment is more than single, domestic enterprises have not yet to invest enough; as the real investment man body of industrialized development, enterprises have not been blended into the development chains in a real sense; (5) currently, China's investment in technical research and development of renewable energy is inadequate, leading some advanced techniques and equipment to severe dependence on importation. This has plunged the industrial development into a fairly passive situation.

With regard to the abovementioned problems in China's renewable energy development policy, standing on the point of long and effective system in renewable energy development, we have carried out systematic and insightful thought upon the policy optimization and innovation. It is hereby advised that importance should be attached to the following aspects in China's renewable energy development policy:

(1) Improving the effectiveness of policy completeness and policy grouping.
(2) Enhance the policy innovation in policy regions, form ''Extensive Promotion–Regional Innovation–Extensive Promotion'' benign cycle.
(3) Construct the regional echoing mechanism for clean development mechanism (CDM).
(4) Enlarge investment on research and development, realize the localization and domestic manufacturing of renewable energy equipment.
(5) Develop process management, ensure the effective role of policy.
(6) Construct a market investment and financing system with introduction by the state, loan from bank and preparation by enterprise itself.

Mention should be made that socialized use and industrialized development of renewable energy is a long-lasting and complicated process, which requires not only policy support from the state but also breakthroughs and development in techniques and markets; relentless support in terms of policy should be offered; continuous breakthroughs should be made in terms of techniques and unceasing cultivation and perfection be carried out in terms of market; only in this way could energy make enormous contributions to the further development of human race.

Acknowledgements

The authors wish to acknowledge the help of the organization and individuals whose literature has been cited in this article. We specially thank Chinese Academy of Science and Chinese Postdoctor Fund Committee for their continued assistance. Research of this article has been supported by the knowledge innovation project of Chinese Academy of Sciences ''Scientific and Technical Current Situation Assessment and Prediction of Biomass Energy in China'' (KSCX2-YW-G-028) and Chinese Postdoctor Research Funds ''Numerical simulation of biomass energy utilization and CO_2 emission'' (2007041084).

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